Range Commanders Council

ELECTRONIC TRAJECTORY
MEASUREMENTS GROUP

IRIG STANDARD 261-00

STANDARD REPORT FORMAT
FOR
GLOBAL POSITIONING SYSTEM (GPS) RECEIVERS AND SYSTEMS ACCURACY TESTS AND EVALUATIONS

WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ABERDEEN TEST CENTER
NATIONAL TRAINING CENTER

ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT

30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR ARMAMENT CENTER
AIR WARFARE CENTER
ARNOLD ENGINEERING DEVELOPMENT CENTER
GOLDWATER RANGE
UTAH TEST AND TRAINING RANGE

NEVADA TEST SITE

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13. ABSTRACT *(Maximum 200 words)*

This document is a guideline for Global Positioning System (GPS) accuracy reports. The standard report format outlined in this document provides guidance for preparing high level accuracy reports on commercial and military GPS receivers and GPS instrumentations systems.

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STANDARD REPORT FORMAT
FOR
GLOBAL POSITIONING SYSTEM (GPS) RECEIVERS AND SYSTEMS ACCURACY TESTS AND EVALUATIONS

FEBRUARY 2000

Prepared by

ELECTRONIC TRAJECTORY MEASUREMENTS GROUP
RANGE COMMANDERS COUNCIL

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U.S. Army White Sands Missile Range,
New Mexico 88002-5110

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APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General

The Electronic Trajectory Measurements Group (ETMG) of the Range Commanders Council (RCC) prepared this document as a guideline for Global Positioning System (GPS) accuracy reports. The ETMG solicits reports documenting accuracy testing on commercial and military GPS receivers and GPS instrumentation systems. These reports are submitted to the Secretariat for archiving in a centralized repository. The Secretariat periodically publishes abstracts from all GPS accuracy reports on file. The range commanders highly recommend that all GPS accuracy reports submitted to the Secretariat for archiving conform to this report standard.

1.2 Scope

The standard report format outlined in this document provides guidance for preparing high-level accuracy reports on commercial and military GPS receivers and GPS instrumentation systems. This report format is not intended to provide standardization for publishing detailed and in-depth GPS performance test reports. The guidelines in this document standardize the mathematical equations used to determine GPS accuracy and the units of measure to quantitatively display these results. This report format also provides guidance on documenting the accuracy of inertial reference units (IRUs) that are commonly coupled with today's GPS instrumentation systems.

1.3 Purpose

a. This report format provides a means for both technical and non- technical personnel to obtain a short and easy-to-read report identifying the accuracy and reliability of a GPS receiver. Use of GPS-based time/space position information (TSPI) systems and training systems is increasing at all Department of Defense (DOD) test and training ranges. Test and program managers often question the accuracy and reliability of the available GPS-based systems; as a result, many of the test and training ranges have performed accuracy and reliability testing on various GPS receivers and instrumentation systems. These results normally are published and available for personnel to review at each range.

b. The ETMG has initiated an effort to collect existing and future GPS accuracy reports for archiving at the RCC Secretariat (rcc@wsmr.army.mil; 505-678-1107, DSN 258-1107). The Secretariat periodically compiles abstracts of the test reports and keeps them on file to provide a single source for obtaining data on how a particular GPS system performed when tested for accuracy and reliability. This database of reports will allow someone planning to install a new system on their range, or to use an existing system, to ascertain whether that system has already been evaluated and, if so, to obtain the results. The availability of a single archive for GPS accuracy reports could prevent unnecessary duplicative testing on a GPS system.

c. For a meaningful comparison of accuracy reports on GPS systems that have been tested, the data should be presented in a standard format. A wide variety of formats is currently being used, resulting in information (e.g., units of measure, data plots, mathematical formulas used in calculating the data, etc.) being presented many different ways. The format differences make comparing test results difficult. The test environment, test platform, and test description sections, in particular, should be presented in a consistent format. These sections often are either not well defined or are missing entirely from the reports.

d. This report format will attempt to correct these deficiencies and make meaningful comparison of future GPS accuracy and reliability test results much easier. The ETMG and the range commanders strongly encourage the use of this standard format for compiling and publishing future results of GPS accuracy testing.

CHAPTER 2

ACCURACY REPORT FORMAT AND EXPLANATIONS

2.1 Abstract

The Abstract and Executive Summary (see para 2.2) are the only portions of the report that are published by the Secretariat. Use Standard Form (SF) 298 (latest revision), Report Documentation Page, to prepare the abstract. Appendix A provides a sample SF 298. Use of key words such as GPS, accuracy, and receiver type is highly recommended. The length of the actual abstract (block 13) is limited to a maximum of 200 words.

2.2 Executive Summary

Limit the Executive Summary to one page. The selected audience is the nontechnical person who will probably not read the entire document. The Executive Summary should:

- Identify the organization that performed the test.
- State the reason for testing and the objectives to be met by conducting the test.
- Identify the test location.
- Describe the type of GPS receiver or GPS instrumentation system evaluated, identify the type of truth source(s) used, and provide a description of the test environment.
- Explain how the test was conducted to meet the objectives.
- Provide a brief synopsis of the test results.
- State any conclusions reached based on the test results.

2.3 Table of Contents

List all headings contained in the individual accuracy report. Use a numbering system to identify the various sections of the report. Include lists of figures, tables, and/or appendices if any or all of these items are contained in the report.

2.4 Introduction

Provide enough information to "set the stage" for the remainder of the report. Limit this section to a half page, if possible.

2.4.1 Background

Describe the events leading up to the test. Identify who required the testing and why the test was necessary. State where the test was conducted and who the primary participants were. Limit this section to one page, if possible.

2.4.2 Authority

State who authorized the test and who the sponsors were.

2.5 Test Article Description

Provide a detailed description of the GPS receiver or GPS instrumentation system being tested. Describe the exact configuration of the equipment under test (EUT) and list items related to the configuration of the EUT, including:

- The exact manufacturer and model number of the EUT
- All standard capabilities and characteristics of the EUT
- Additional nonstandard features or options installed on the EUT
- The receiver tracking mode(s): P-code (Y) or CA-code
- Whether the EUT used differential corrections real-time, or whether differential corrections were done during post processing
- Whether lever arms for the antenna and for the IRU were used. (If lever arms were used, provide the exact lever arm data and identify the point on the test platform at which the lever arm data was calculated.)
- The type of antenna used and its characteristics (for both the EUT and any reference receiver that may have been used)
- Antenna mask angle used
- Any other data that would allow someone to precisely duplicate the setup used on the EUT.

2.6 Test Objective

Document all test objectives. Explain why and how the objectives were generated.

2.7 Test Description

Thoroughly describe the test and all specifics associated with conducting the test. Document all instrumentation, software, and unique test equipment used, as well as other relevant data regarding the test. Describe in detail the truth source used to obtain the accuracy comparison. Address the accuracy of the source. Truth sources for dynamic tests could be optical, laser, radar, etc. Static truth sources may only be a surveyed point. Regardless of the type of truth source used, it is important to document how the accuracy reported was derived.

2.7.1 Test Platform

Describe the test platform used to mount the EUT (e.g., if the EUT was in an airborne pod, document the type of aircraft on which it was flown). Identify all aspects of the aircraft configuration (e.g., the wing station on which the item was mounted, the type of bomb rack, or any special setups in the cockpit, etc.). If lever arms were used, note the location on the aircraft at which the lever arms were calculated. If the test platform was a ground-based or water-based vehicle, document all specifics regarding the method for mounting the EUT. Also document such things as the type of antenna used, the location at which the antenna was mounted, whether any special rigging or mounting hardware was required, the truth source, the calibration standard, etc.

2.7.2 Test Environment

Because the test environment can affect the accuracy of a GPS receiver, this section should document the receiver's accuracy. The number and position of satellites in a constellation, the orientation of the antenna, the terrain masking, and ionospheric conditions are determining factors. To measure the true accuracy of a GPS receiver, a controlled and repeatable environment is recommended. Major GPS test ranges use satellite signal simulators (SSSs) to provide the radio frequency (RF) signals. If the test is performed using the satellite constellation, track and record the variables. This includes the number of satellites in view during the test period [maximum/minimum (MAX/MIN)] and the calculated dilutions of precision (DOPs) for the set of satellites in view (MAX/MIN). Describe the test setup, including the number of truth sources used on the test and their location in relation to the EUT. An appendix may be used to provide a diagram or map of the test setup. If used, the appendix should include a description of the GPS reference receiver (RR), documenting the type and manufacturer of the RR and the capabilities and performance characteristics. Also document the location of the RR in relation to the EUT.

2.7.3 Test Plan

Provide a brief description of the test plan. Also document the point in the test where data were scheduled to be collected and for how long, and when truth source data were scheduled to be collected. For airborne tests, the type of maneuvers performed, including the altitudes and airspeeds at which the maneuvers were scheduled to be executed, should be documented. For ground-based tests, identify the various ground speeds called for in the test plan and any special maneuvers to be executed.

2.8 Test Results Summary

Summarize all collected data and present it in a standard format, as identified in chapter 3.

2.8.1 System Functional Results Summary

Provide, if available, data concerning the overall performance of the EUT (e.g., how well the receiver maintained lock on the satellites, the number of satellites normally tracked and used in the calculation of the solution, etc.). If a datalink was used, identify any datalink dropouts. Document multipath at the EUT or at the RR location, if it was recorded and calculated. Note any system failures experienced during the testing. Include a brief description of the failure, along with any diagnosis that was conducted to determine the cause of the failure. This section should be omitted if not required.

2.8.2 System Accuracy Results Summary

This section should contain all accuracy results. Use the plots and charts identified in chapter 3 to present the data.

2.8.2.1 Truth Source Summary

This section should provide truth source data.

2.8.2.2 Velocity Accuracy Summary

If the velocity accuracy of the EUT was calculated and measured against a truth source, document the results. This section should be omitted if not required.

2.8.2.3 Acceleration Accuracy Summary

If the acceleration accuracy of the EUT was calculated and measured against a truth source, document the results. This section should be omitted if not required.

2.8.2.4 Attitude Accuracy Summary

If the EUT included an IRU, and the attitude accuracy of the IRU was calculated and measured against a truth source, document the results. This section should be omitted if not required.

2.8.2.5 Attitude Rate Accuracy Summary

If the EUT included an IRU, and the attitude rate accuracy of the IRU was calculated and measured against a truth source, document the results. This section should be omitted if not required.

2.9 Conclusions

This section should contain conclusions derived from the test results. Key items that should be addressed include the test objectives and whether the test results met the objectives as defined in the test plan. Document any lessons learned from the test, including recommendations based on the results achieved.

2.10 References

List all references cited in the report. This section should be omitted if no references were used.

2.11.1 Other

Any additional comments.

2.11.1 Appendices

If necessary, include appendices to the main report. Items that may be included as appendices are:

- Additional data plots (see appendix C for sample plots).
- Detailed information on the truth sources used in the test (e.g., calibration reports on the truth sources, etc).
- List of failures and/or problems encountered during the test.
- Detailed description of the data reduction software used to obtain the test results.
- Any additional data not covered in the minimum required data sections that the author wishes to present.

2.11.2 Figures

Test results, setup, and configurations may require the use of figures to adequately present the data. Use a standard numbering system for the figures, starting with "Figure 1-1".

CHAPTER 3

DATA CALCULATIONS AND PLOTS

3.1 Data Calculations

a. This section summarizes the following five methods used to provide a measure of system performance in navigation:

- Circular error probable (CEP)
- Height error probable (HEP)
- Spherical error probable (SEP)
- Distance root mean square (DRMS)
- Mean radial spherical error (MRSE).

b. CEP, HEP, SEP, DRMS, and MRSE state nothing about the quality or accuracy of the data used in computing the location of a target. These items are a measure of dispersion and of central tendency.[1]

3.1.1 Circular Error Probable

The CEP is the radius of circle that encloses 50 percent of the probability of a hit in two dimensions. In reference 1, six equations are given for computing the CEP. The preferred equation is

$$CEP = 0.5887(\sigma_x + \sigma_y) \tag{1}$$

which has an accuracy of approximately 3 percent. This CEP is an integral of the bivariate (two-variable) Gaussian probability function in a plane. The parameters σ_x and σ_y are standard deviations of error along two perpendicular axes in a plane, and 0.5887 is a dimensionless constant that was derived using a 50-percent CEP in the integration of a bivariate Gaussian probability distribution.[1]

3.1.2 Height Error Probable

The HEP can be calculated to determine an altitude error independent of the CEP and SEP. The SEP combines both horizontal and vertical errors. Since the vertical error is generally greater than the horizontal error, the SEP will be influenced dominantly by the vertical error; therefore, by computing the HEP, CEP, and SEP, one can better determine the distribution of the errors. In reference 2, a 50-percent HEP is given as

$$HEP = 0.6745\sigma_H \tag{2}$$

The derivation of this equation assumes a Gaussian probability function in the vertical direction. The parameter σ_H is the standard deviation of error in height.

3.1.3 Spherical Error Probable

The above result can be extended to the three-dimensional (3d) case: the SEP. The SEP is an integral of the trivariate (three-variable) Gaussian probability density function over a sphere which is centered at the mean. Two equations were found to compute 50-percent SEP. The first equation is given in reference 3 as

$$SEP = 0.51(\sigma_x + \sigma_y + \sigma_z) \tag{3}$$

The second equation, which is given in references 3 and 4, is

$$SEP \approx \left[\sigma^2(1 - V/9)^3\right]^{1/2} \tag{4}$$

where

$$\sigma^2 = \sigma_x^2 + \sigma_y^2 + \sigma_z^2$$
$$V = 2(\sigma_x^4 + \sigma_y^4 + \sigma_z^4)/\sigma^4$$

Reference 4 claims that equation 4 is probably the best of the analytical approximations to compute SEP to within 1 percent whenever $\sigma y/\sigma x \geq 1/2$.

3.1.4 Distance Root Mean Square Error

Reference 3 defines the DRMS as

$$DRMS = \sqrt{\sigma_x^2 + \sigma_y^2} \tag{5}$$

where the probability of being within a circle of radius DRMS varies between 63.2 percent and 68.3 percent. A parameter frequently used is the 2DRMS, which is defined as

$$2DRMS = 2 \times DRMS = 2\sqrt{\sigma_x^2 + \sigma_y^2} \tag{6}$$

where the probability of being within a circle of radius 2 DRMS is between 95.4 percent and 98.2 percent.

Note: 2DRMS should not be confused with 2-D RMS, the two-dimensional root mean square (rms) error that is essentially identical with DRMS.[3]

3.1.5 Mean Radial Spherical Error

Reference 3 gives the following equation to compute the MRSE:

$$MRSE = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2} \tag{7}$$

with a probability of 61 percent.

3.2 Data Plots

This section provides guidelines for reporting GPS accuracy with respect to other EUTs. It also provides a standard process to report data for high-level management.

3.2.1 GPS Validation

a. Report GPS validation in meters.

b. Conduct static tests over known survey sites.

(1) Sites should be first-order geodetic sites, with data collected in World Geodetic Survey (WGS)-84.

(2) Report statistics in a local tangent plane [Northing, Easting, and Up (N, E, and U)], horizontal [two-dimensional (2d) data, x, y], and vertical data. Provide three-dimensional (3d) statistics.

(3) If two or more GPS systems are evaluated, use a common antenna and collect data at the same time.

(4) Log GPS software versions for systems.

(5) Identify types of GPS measurements used to produce the GPS solution [e.g., L1, L2, code data, carrier phase data, C/A code and P-code differential mode, Wide Area Augmentation System (WAAS)].

(6) Provide update rates of the solution and the differential corrections, if applicable.

(7) Provide signal-to-noise for the satellites, satellites used in the solution, and DOP data.

(8) Evaluate time to first fix (TTFF).

(9) Evaluate the jamming environment.

(10) Include antenna characteristics, mask angles, multipath, other (TBD).

c. Dynamic Solutions

(1) Consider all items listed in paragraphs 3.2.1b(1) through 3.2.1b(10).

(2) Specify in meaningful statistics the accuracy of the system used as the dynamic standard (e.g., mean, standard deviation, CEP, SEP, rms, DRMS, 2 DRMS). (See section 3.1.4 for complete definition.)

(3) If an IRU is used to aid the GPS solution, identify the type of IRU and provide a brief statement explaining the method of integration.

(4) If multiple GPS antennas are used, provide their relative positions in the standard aircraft orientation, positive x out the nose, positive y out the right wing, and z positive down. Identify the reference point on the vehicle and offsets to the EUTs. Data should be transformed to the reference point.

(5) Specify vehicle dynamics.

3.2.2 Data Reporting

a. Provide the following:

- time of test
- place of test
- standard used for comparison
- number of points in sample
- mean
- standard deviation
- number of data points data at 50th percentile, 68th percentile (1 sigma), 90th percentile (2 sigma), 95th percentile, and 99th percentile (3 sigma)
- maximum data value
- minimum data value.

b. Tabulate the statistics defined in section 3.1, with local tangent plane data provided to the reference point (N, E, U system, as an example).

COMPARISON: RISPO- Trimble

Date	Vehicle	Sample size	Mean	Standard Deviation			rms	2 DRMS	CEP	HEP	SEP
			NEU meters	N Meters	E	U					
1/2/97	Tank	123000	1.2,2.0,6.9	3.0,	2.8,	5.1	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx
1/3/97	Tank	123400	1.3, 2.2, 7.9	3.1,	3.2,	7.1	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx
1/4/97	Tank	123700	1.4, 2.4, 8.9	3.5,	2.2,	8.1	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx

The rms, 2DRMS, CEP, HEP, and SEP are computed in accordance with (IAW) section 3.1. Provide a second table with the percentage of data in the various percentile ranges with the maximum and minimum value count.

Provide the following:

Date	Vehicle	Sample size	Mean	Standard Deviation		
			NEU	N	E	U

Also provide a table of data samples that identifies the number of samples for each percentage of N, E, and U.

Date	Vehicle	COMPARISON
1/2/99	P-3	RISPO - Ashtech

If a simulator is used as the truth source, provide a brief description of the scenario.

3.2.3 Jamming Tests Data

State whether jamming tests were performed. If a jamming test was performed it may be classified. Refer to the Security Classification Guide to determine.

3.2.4 Antenna Tests and Evaluation

State whether antenna tests were performed. If it is the primary test provide report.

3.2.5 Inertial Reference Unit Data

Provide the attitude (degrees), acceleration rate (meters per second 2), and velocity (meters per second).

3.2.6 Meteorological Data

Provide meteorological data for tropospheric and ionospheric corrections applications to the GPS data. Also identify solar flare activity, if present.

3.2.7 Test Findings

Include the type of GPS data. The following items should be addressed:

- Differential GPS: yes/no
- Signals used: L1-L2 [C/A, P(y)-code]
- Type of processing: code, code and carrier phase, carrier phase only
- Aided: yes/no
- Mean and standard deviation: horizontal position and velocity, vertical position and velocity
- rms and CEP for horizontal data 2d mode
- rms and HEP for vertical data
- rms and SEP for 3d mode

If only one set of values is to be used, the rms (see section 3.1) should be used.

3.2.8 <u>Editing</u>

Explain the degree to which editing and/or filtering of data are used. Wild points are eliminated at the 4-sigma level. Provide a count of the MAX/MIN values.

3.2.9 <u>Plots</u>

a. When plots are used to explain the data, consider the following:

- Position for Northing, Easting, and Up data versus time (time GMT)
- Velocity for Northing, Easting, and Up data versus time (time GMT)
- Acceleration for Northing, Easting, and Up data versus time (time GMT)
- Delta Northing versus delta Easting
- Delta altitude versus delta Easting
- Attitude data versus time. Select one of the following degrees:
    - Roll, pitch, and heading
    - Roll rate, pitch rate, and heading rate
    - Roll rate change, pitch rate change, and heading rate change
- DOP versus time
- Number of space vehicles (SVs) versus time
- Altitude plot versus time
- XY versus time

b. Provide histograms of percentage of data for each element N, E, and U. These data provide an indication of the data distribution and give a quick evaluation of the quality of the data.

3.3 References

1. Siouris, G.M.: Aerospace Avionics Systems - A Modem Synthesis, Academic Press, Inc, 1250 Sixth Avenue, San Diego, California 92101-4311, Appendix A. 1993.

2. Gates, L.J.: Height Error Probable Notes, NAWCWPNS, Metric and TSPI Systems Design Branch, Code 522KOOE, Point Mugu, California, 1982.

3. Seeber, G.: Satellite Geodesy, Walter de Gruyter & Co., D-1000 Berlin 30, 295-297, 1993.

4. Childs, D.R., Coffey, D.M., and Travis, S.P.: "Error Measures for Normal Random Variables," IEEE Transactions on Aerospace and Electronic Systems, AES-14(l), 6467, January 1978.

5. Institute of Navigation (ION) Standard (STD) 101, Recommended Test Procedures for GPS Receivers, Revision C, 27 January 1997.

APPENDIX A

SF 298 - REPORT DOCUMENTATION PAGE

(A sample of SF 298 is provided in this appendix.)

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13. ABSTRACT *(Maximum 200 words)*

This test report evaluates the Advanced Range Data System (ARDS) Global Positioning System (GPS) functional capability and system accuracy exhibited under non-ideal daily conditions.

Operational tests were conducted on the Naval Air Warfare Center Weapons Division (NAWCWPNS) Land Ranges using an F/A-18 aircraft performing various high-, medium-, and low-dynamic maneuvers. Aircraft position, velocity and acceleration were determined by the Land Range Time Space Position Information (TSPI) truth source tracking sensors. Aircraft attitude and attitude rate were determined by the F/A-18 Inertial Navigation System (INS). During post mission data analysis, these statistics where then compared to the ARDS determined values for the same statistics.

Test results showed ARDS has an effective functional capability to provide GPS based TSPI during non-ideal daily conditions. Evaluated system accuracy showed ARDS will provide TSPI nearly as accurate as the Land Range TSPI truth source tracking sensors and F/A-18 INS. Additional conclusions are shown concerning operation procedures, software problems, pod loading procedures, and equipment versions.

14. SUBJECT TERMS
Global Positioning System (GPS); Differential GPS (DGPS); Range Applications Program (RAP); Range Applications Joint Program Office (RAJPO); Advanced Range Data System (ARDS); Accuracy, Position, Velocity, Acceleration, Attitude, and Attitude Rate.

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Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

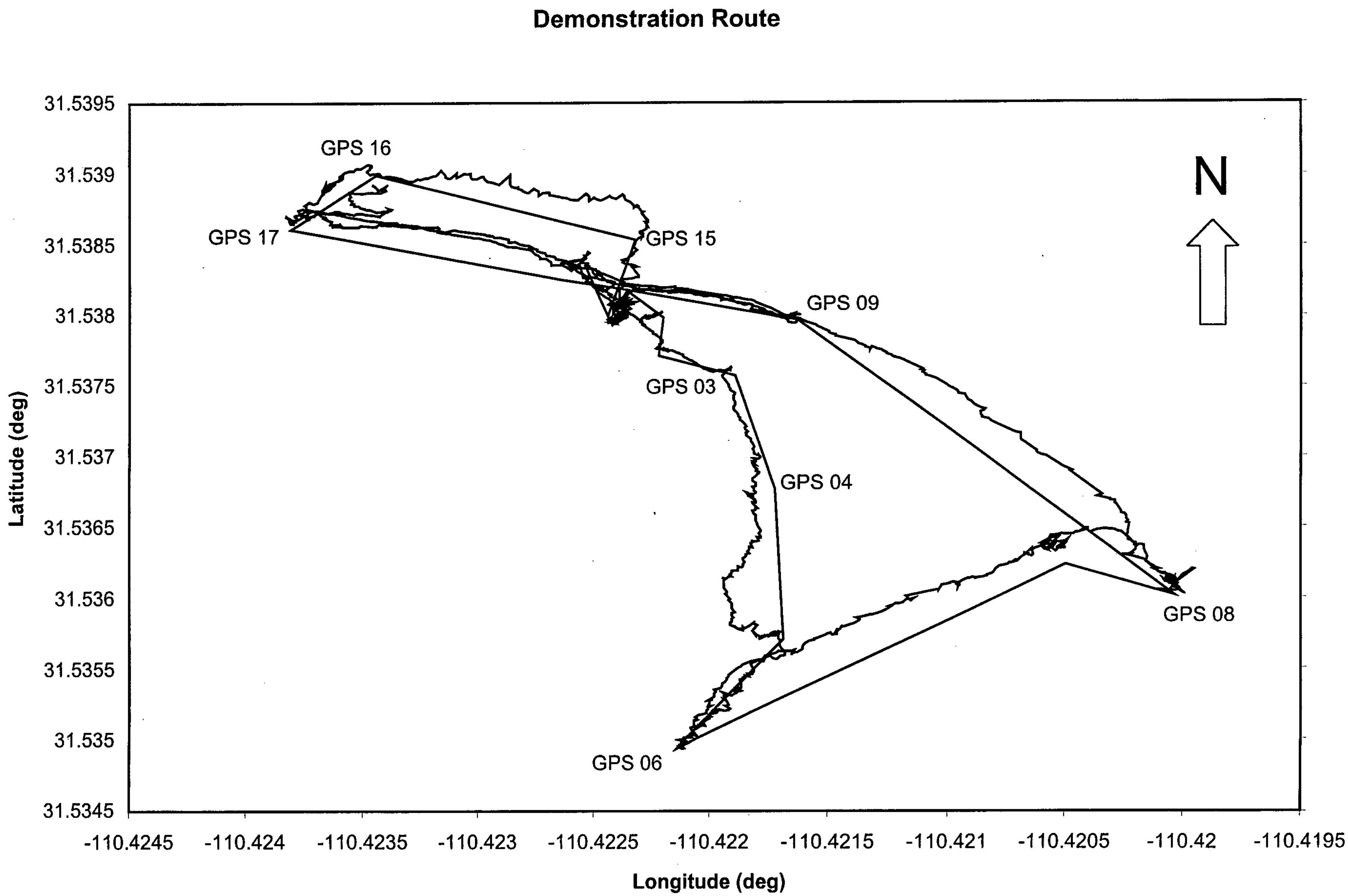
APPENDIX B

ACRONYMS

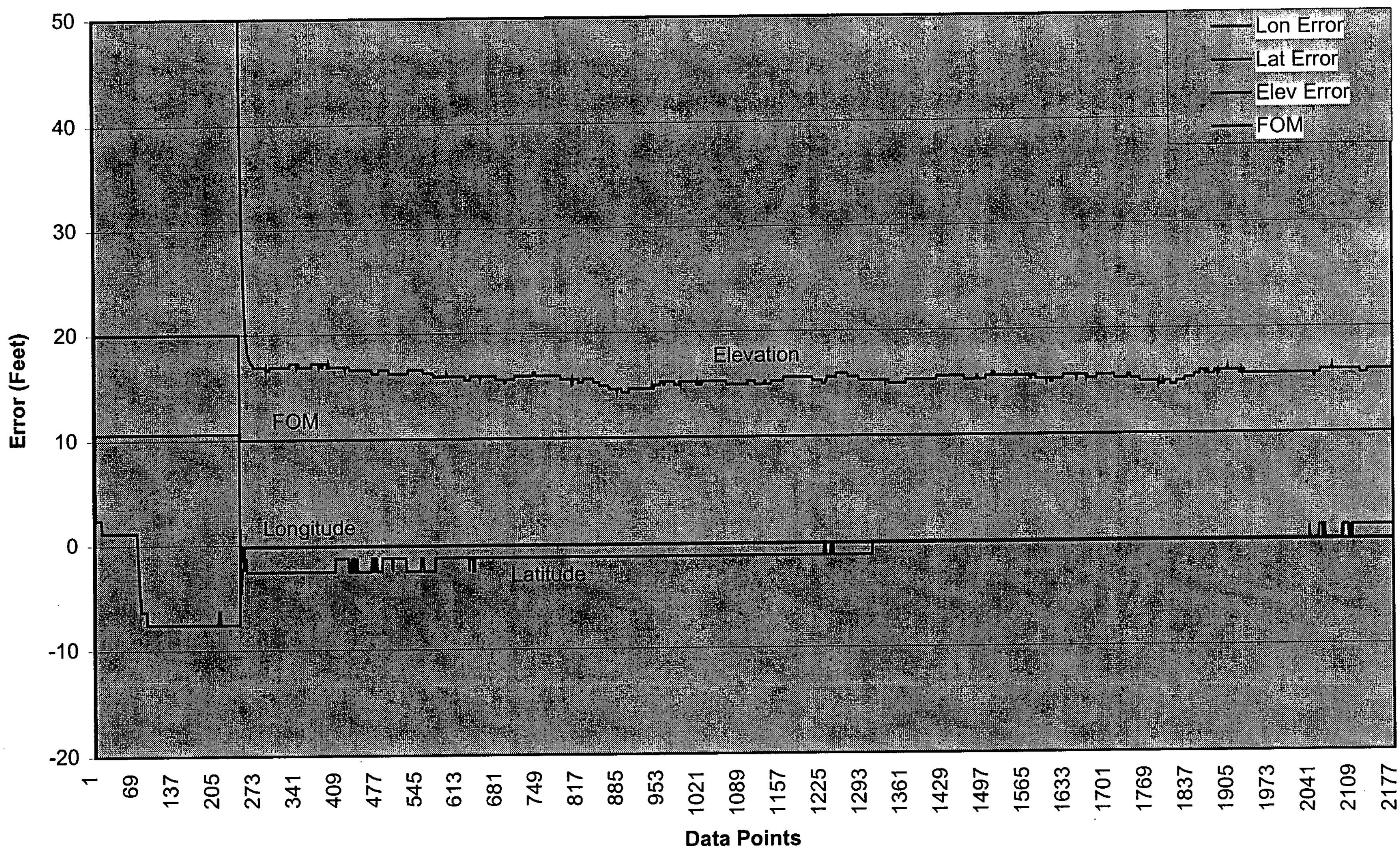
2d	two-dimensional
3d	three-dimensional
CEP	circular error probable
DGPS	Differential GPS
DOD	Department of Defense
DOP	dilution of precision
DRMS	distance root mean square
ETMG	Electronic Trajectory Measurements Group
EUT	equipment under test
GMT	Greenwich Mean Time
GPS	Global Positioning System
HEP	height error probable
IAW	in accordance with
ION	Institute of Navigation
IRU	inertial reference unit
MAX/MIN	maximum/minimum
MRSE	mean radial spherical error
RCC	Range Commanders Council
RF	radio frequency
rms	root mean square
RR	reference receiver
SEP	spherical error probable
SF	standard form
SSS	satellite signal simulator
STD	Standard
SV	space vehicle
TSPI	time/space position information
TTFF	time to first fix
WAAS	Wide Area Augmentation System
WGS	World Geodetic Survey

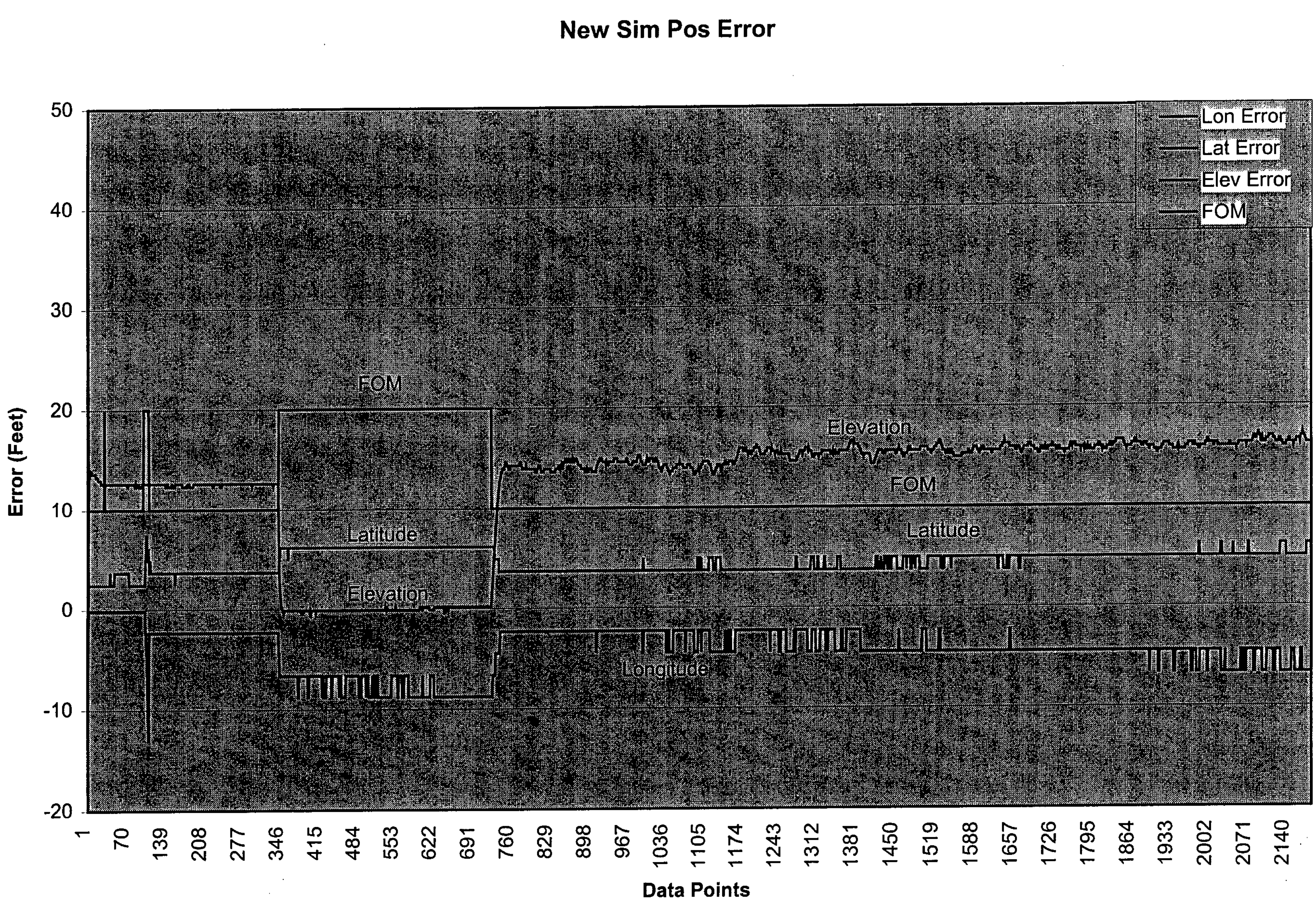
APPENDIX C

SAMPLE PLOTS


Demonstration Route
GPS 16
GPS 17
GPS 15
GPS 09
GPS 03
GPS 04
GPS 08
GPS 06
N
31.5395
31.539
31.5385
31.538
31.5375
31.537
31.5365
31.536
31.5355
31.535
31.5345
Latitude (deg)
-110.4245
-110.424
-110.4235
-110.423
-110.4225
-110.422
-110.4215
-110.421
-110.4205
-110.42
-110.4195
Longitude (deg)

New Sim Pos Error




New Sim Pos Error
Error (Feet)
50
40
30
20
10
0
-10
-20
1
70
139
208
277
346
415
484
553
622
691
760
829
898
967
1036
1105
1174
1243
1312
1381
1450
1519
1588
1657
1726
1795
1864
1933
2002
2071
2140
Data Points
Lon Error
Lat Error
Elev Error
FOM
FOM
Latitude
Elevation
Longitude
Elevation
FOM
Latitude

New Sim Pos Error